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October 16, 1991

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re: Petition of Constellation Communications, Inc.
RM-7771

Dear Ms. Searcy:

Enclosed on behalf of American Mobile Satellite Corporation ("AMSC") is an original and five copies of its opposition to the above-referenced petition for rulemaking filed by Constellation Communications, Inc. ("Constellation"). AMSC is consolidating its response to the Constellation petition with its response to two other petitions for rulemaking (RM-7773 and RM-7805) that raise similar issues and have the same filing deadlines. To insure that AMSC's pleading is associated with each of the rulemaking files, under separate cover we also are submitting this same pleading in the other two files.

Please contact the undersigned if there are any questions.

Very truly yours,

Bruce D. Jacobs

BDJ:jlm

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of the Petition of CONSTELLATION COMMUNICATIONS, INC. Amendment of Parts 2 and 25 of the Commission's Rules to Implement LEO Satellite Systems in the RDSS Bands and Grant a Pioneer's Preference	)	RM-7771
In the Matter of the Petition of TRW INC. Amendment of Sections 2.106 and 25.141 of the Commission's Rules to Allocate Spectrum for and to Establish Other Rules and Policies Pertaining to Satellite Systems in the RDSS Bands	)	RM-7773
In the Matter of the Petition of ELLIPSAT CORPORATION to Amend Sections 2.106, 25.141 and 25.201 of the Commission's Rules	)	RM-7805

OPPOSITION OF AMERICAN MOBILE SATELLITE CORPORATION

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Date: October 16, 1991

Summary

AMSC urges the Commission to reallocate a portion of the Radiodetermination Satellite Service uplink frequencies to the Mobile Satellite Service so that the spectrum can be used to supplement the current MSS allocation. The U.S. MSS system faces a difficult international process of coordinating for a sufficient share of the limited amount of spectrum currently available. The allocation of additional frequencies to MSS from the RDSS bands would help to alleviate that shortage. Moreover, AMSC has demonstrated that it could add the new frequencies at a nominal cost.

The three Petitioners -- Constellation, TRW and Ellipsat -- appear to agree with AMSC that the RDSS bands should be used for a broad range of mobile satellite services. The Petitioners, however, contend that the RDSS frequencies should be used to license several new satellite systems. This contention is based on the erroneous assumption that the RDSS spectrum can support these new systems. In fact, use of the RDSS spectrum is severely constrained by power restrictions and other constraints established by the 1987 Mobile WARC and the Commission to protect other services that operate in the bands. These constraints make it particularly difficult to put a high-capacity satellite system into the RDSS bands, particularly one that uses non-geostationary satellites.

AMSC opposes as unworkable the proposals of Constellation and TRW to permit higher-powered satellite systems to operate in the RDSS downlink band. The Constellation proposal to expand the

band fails to take into account the increased interference that would be caused to mobile receivers by microwave ovens. The TRW proposal to simply increase downlink power directly contradicts the evidence that such an increase in power would cause substantial harmful interference to existing users.

The actual applications of Constellation, TRW and Ellipsat further demonstrate the futility of attempting to use the RDSS bands for new stand-alone MSS systems. The proposed systems would cost between $230 million and $1.3 billion, yet the largest of the systems, operating without interference to existing users, would have less than a hundred voice channels.

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FEDERAL COMMUNICATIONS COMMISSION
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OPPOSITION OF AMERICAN MOBILE SATELLITE CORPORATION

American Mobile Satellite Corporation ("AMSC"), by its attorneys, hereby opposes the above-referenced Petitions for Rulemaking filed by Constellation Communications, Inc. ("Constellation"), TRW Inc. ("TRW") and Ellipsat Corporation ("Ellipsat").[1/] Constellation, TRW and Ellipsat each request

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1/ AMSC is the licensee of the U.S. Mobile Satellite Service system. See Tentative Decision, 91-240 (August 2, 1991). AMSC is a consortium of entities that filed MSS applications (continued...)

that the Commission modify the rules for the Radiodetermination-Satellite Service ("RDSS") to facilitate the licensing of new mobile satellite systems, particularly those systems for which they each have submitted applications. AMSC is not opposed to competition. As AMSC demonstrated previously, however, the RDSS spectrum is too limited to support a single MSS system, let alone the multiple systems envisioned by Constellation, TRW and Ellipsat.[2/] Thus, rather than make the changes proposed by Petitioners, AMSC continues to urge the Commission to reallocate the spectrum to MSS and assign the spectrum to AMSC, which has shown that it needs the spectrum and has a realistic proposal for putting the spectrum to use.

1/(...continued)
in 1985 and includes among its shareholders Hughes Communications Mobile Satellite Service, Inc.; McCaw Space Technologies, Inc.; and MTEL Space Technologies Corporation. Since receiving its license in 1989, AMSC has invested tens of millions of dollars into the development of its system and has begun the construction of its first satellite.

AMSC is filing this opposition as a consolidated pleading because the issues raised in each of the petitions are largely identical. A consolidated pleading should facilitate review of these issues in a comprehensive fashion and is consistent with the Commission's rules, since it appears that all of the petitions will be reviewed by the same Commission staff. See 47 C.F.R. § 1.44. When an issue is discussed that relates only to a specific Petitioner, it is identified clearly as such.

Comments concerning the Petitions of CCI and TRW originally were due September 13, 1991. The Commission extended the comment period to October 16, 1991 and added a request for comments on the Ellipsat Petition. Public Notice (September 13, 1991).

2/ See AMSC Petition (June 3, 1991).

Background

The RDSS bands are of limited utility for satellite service.[3/] A large portion of the RDSS uplink band is shared with both Radio Astronomy (1610.6-1613.8 MHz) and Radio-navigation-Satellite systems (1610-1616.5 MHz). There are at least six radio astronomy observatories in the United States that operate in this band, and the Soviet Union's global aeronautical navigation system ("Glonass") will operate worldwide in the 1610-1616.5 MHz band. The uplink band also is allocated internationally for fixed services and is in use for terrestrial services in a number of foreign countries. The RDSS downlink band (2483.5-2500 MHz) is widely used for terrestrial fixed services, particularly outside the United States, and is part of the Industrial, Scientific and Medical ("ISM") allocation (2400-2500 MHz), which includes millions of microwave ovens in the United States.

As a result of these other uses of the bands, the 1987 Mobile Services World Administrative Radio Conference ("WARC"), in allocating the frequencies internationally to RDSS, adopted several critical restrictions on use of the bands by RDSS systems.[4/] These include a severe limit on the power of RDSS

3/ The RDSS mobile links are at 1610-1626.5 MHz (earth-to-space) and 2483.5-2500 MHz (space-to-earth).

4/ See e.g., RR Article 28, Nos. 2556-2559; RR Article 8, Nos. 733A, 733E, 753A, and 753B.

transmissions and a coordination requirement for airborne and ground-based RDSS terminals using the uplink band.[5/] In addition, the conference excluded RDSS from receiving safety service status, which makes it more difficult to coordinate RDSS systems with systems such as Glonass, and adopted secondary allocations for RDSS in ITU Regions 1 and 3.

The Commission itself established additional restrictions on RDSS systems as part of the licensing of domestic RDSS systems. These restrictions include requirements that RDSS systems use pseudo-random-noise codes and random access time division multiplex techniques, limitation of RDSS communications to short bursts, and relegation of non-RDSS services provided by RDSS systems to ancillary status.[6/]

These restrictions have severely limited the utility of the bands for two-way mobile communications by satellite.[7/] This is demonstrated by the applications that were filed earlier by

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5/ See RR Article 28, No. 2548a; RR Article 11, No. 1107.2.

6/ See Notice of Proposed Rulemaking in Gen. Docket Nos. 84-689 and 84-690, 49 Fed. Reg. 36512 (September 18, 1984); Second Report and Order, 104 FCC 2d 650 (1986). To protect radio astronomy further, the Commission imposed a requirement that RDSS terminals in the vicinity of a radio astronomy facility restrict their operations to brief intervals timed to avoid interference with astronomy observations. Id.

7/ The U.S. has proposed that a primary MSS allocation be added to the RDSS bands at the 1992 World Administrative Radio Conference. See United States Proposals for the World Administrative Radio Conference, Department of State Publication 9903 (July 1991).

Ellipsat and Motorola Satellite Communications, Inc. ("MSCI").[8/] Ellipsat and MSCI propose to construct and operate systems that do not conform to the international rules or to the Commission's restrictions, particularly with respect to their power levels. See AMSC Petition (June 3, 1991). Moreover, if the Ellipsat and MSCI systems were to comply with the requisite power levels, they would have so little capacity that the systems obviously would not be financially feasible. Id.

AMSC has offered a practical alternative to the problems presented by the RDSS bands, recommending that the Commission reallocate the 1616.5-1626.5 MHz band to MSS, to be paired with an alternative downlink band.[9/] Due to a severe international shortage of MSS spectrum, AMSC needs access to what usable spectrum there is in the RDSS bands.[10/] AMSC has made a specific proposal to use the RDSS uplink band, requesting authority to modify two of its satellites to add the frequencies. AMSC has demonstrated that it could add the new frequencies to its system at a cost of $1-10 million for each satellite.

The Petitions of Constellation, TRW and Ellipsat are based on the assumption that there is sufficient spectrum in the RDSS

8/ Application of Ellipsat Corporation, File No. 11-DSS-P-91(6) (November 5, 1990); Application of Motorola Satellite Communications, Inc., File Nos. 9-DSS-P-91(81) and CSS-91-010 (December 3, 1990).

9/ AMSC has proposed the following as alternative downlinks: 1515-1525 MHz, or a ten megahertz segment of the 1850-1990 MHz 2110-2130 MHz, or 2160-2180 MHz bands.

10/ See e.g., AMSC Comments, Gen. Docket No. 89-554 (December 3, 1990 and April 12, 1991).

bands to support several new MSS systems.[11/] In order to improve the utility of the RDSS downlink band, Constellation and TRW each propose changes in the current allocation. Constellation proposes that the Commission expand the RDSS downlink band so that the capacity of spread spectrum systems can be increased without also increasing their power in any 4 Khz band. TRW proposes that the Commission relax the power limit in the downlink band by 10 dB to enable system capacity to be increased to levels sufficient for voice and data transmissions.[12/]

Each of the Petitioners also filed an application which illustrates how it would implement its proposal. Constellation, which is a new venture composed of companies whose experience is in the construction or launch of small satellites for the military, proposes to launch and operate 48 low-Earth orbit satellites, each of which it claims will be capable of providing fifty channels of voice service. Constellation estimates the cost and operation of its system for one year to be $292 million.

11/ The Petitioners propose that the Commission change its RDSS rules to include mobile voice and data services in the definition of Radiodetermination Satellite Service. In addition, each of the Petitioners has submitted an application for a system that would primarily provide mobile voice and data communications, rather than position location service. The kinds of systems being proposed by Petitioners require more spectrum than an RDSS system. By contrast, an RDSS system provides only low-throughput data services and thus does not require substantial spectrum to provide service to a significant number of users.

12/ Ellipsat's proposal also includes a recommendation that the Commission authorize operation of feeder links in the RDSS bands.

TRW is a large aerospace and electronics corporation that also has a background in the construction of military satellites. The TRW system would consist of 12 medium-Earth orbit satellites; its estimated cost of construction and first-year operation is $1.3 billion. Ellipsat is a new venture. Its technical proposal, based on amateur radio satellite designs, is for 24 satellites in elliptical orbit, each of which has an expected life of five years. Ellipsat estimates the cost of its system at approximately $230 million.

Discussion

The issue presented by these Petitions and their associated applications is whether the public interest is better served by making the RDSS band available for (a) the possible development of new satellite systems such as those of Constellation, TRW and Ellipsat or (b) the implementation of the AMSC system. Based on the evidence in the record, it is abundantly clear that there is not enough spectrum in the RDSS bands for even one of the systems that Petitioners are proposing and that their proposals to upgrade the utility of the bands are unworkable. By contrast, if the spectrum is allocated to AMSC, it can and will be put to use in the near future, providing much-needed service to the American public.

I. The Available RDSS Band Spectrum is Severely Limited

All of the Petitions are based on unrealistic assumptions about the availability of the RDSS band spectrum. As discussed above, potential use of the spectrum for mobile satellite service is severely limited. Of the 16.5 MHz that is allocated to RDSS in the Earth-to-space direction, all but 10 MHz also is used for Radio Astronomy and Radionavigation services. AMSC has demonstrated previously that non-geostationary MSS systems will not be able to share with these services. The systems proposed by Petitioners are no exception. As demonstrated in the attached Technical Appendix, each of the systems would cause harmful interference to radio astronomy observatories and to the Glonass system.

The RDSS downlink band is an even bigger problem than the uplink band. The existing power limits make it virtually impossible to use any of the downlink band for a high-capacity mobile satellite service. Moreover, as discussed below, the Constellation and TRW proposals for improving the utility of the downlink band are unworkable.

To make matters worse, whatever usable spectrum the RDSS band actually offers for future satellite systems is not automatically available in its entirety to a U.S. domestic system. To the contrary, a U.S. system will have to coordinate its use of the band with foreign systems that undoubtedly will seek access to the band for their own systems. Already, there are at least preliminary indications that Inmarsat and the

Canadian MSS operator will propose to use the RDSS band for their MSS systems and others are likely to follow. This fact is illustrated well by the current situation involving the MSS band, which contains roughly the same amount of spectrum as the RDSS band and has no power limits and virtually no competing terrestrial users in the United States.[13/]

II. The Constellation and TRW Proposals to Increase the Utility of the RDSS Downlink Band Are Unworkable

Constellation and TRW attempt to improve the opportunities for MSS systems to use the RDSS bands by proposing ways to alleviate the problem of the power limits on the downlink band. Constellation proposes to expand the downlink band and TRW proposes to relax the power limit. As discussed more fully in the Technical Appendix, however, these proposals cannot be implemented. The Constellation proposal ignores the presence of ISM interference, which will only increase as the downlink band is expanded. The TRW proposal is based on the incorrect assumption that the current power limits are unnecessary to protect terrestrial users from interference caused by low-Earth orbit systems such as that proposed by TRW. In fact, as demonstrated in the Technical Appendix, the existing power limits are too restrictive for TRW's non-geostationary satellite system. The existing power limits were developed for geostationary

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13/ The Commission has allocated 1545-1559 MHz/1646.5-1660.5 MHz to MSS. A small portion of this band (.5 MHz) is shared with Radio Astronomy.

satellite systems. The downlinks of non-geostationary systems generate as much power on the Earth's surface as a geostationary system but, unlike a geostationary system, they do so from all angles of arrival, including along the mainbeams of terrestrial receiver antennas. Thus, to protect terrestrial systems from severe harmful interference the power limits need to be made more restrictive for low-Earth orbit MSS systems, not reduced.

III. Petitioners' Applications Are Unrealistic

Perhaps the most telling evidence of the Petitioners' flawed approach to the use of the RDSS band is their specific applications. These applications, after all, exemplify Petitioners vision of the best use of the RDSS bands. As discussed in more detail in the Technical Appendix, the proposed systems would have serious technical problems.

Petitioners' systems would have virtually no capacity. TRW claims that its system would have more than 4,500 voice channels, but in fact, even if all of the RDSS uplink band were available to TRW's system alone, without the need to share with any other domestic or foreign satellite system, the need to avoid downlink interference to terrestrial fixed services would reduce the system's capacity to less than one hundred channels. The Constellation and Ellipsat applications fare even worse when subjected to the same analysis. Their systems would have fewer than ten channels each.

The Constellation and Ellipsat systems also would have extreme problems with reliability. As discussed in the Technical

Appendix, the proposed systems of Constellation and Ellipsat would experience significant gaps in coverage and probable service outages during the eclipse periods that are common for non-geostationary satellites. In addition, the proposed systems would be extremely expensive to construct, particularly in light of their minimal capacity.

Finally, none of these systems conforms to the Commission's requirements for RDSS systems. As discussed in the attached Technical Appendix, the designs of the three systems will not permit the frequency sharing that the Commission has established as a requirement for RDSS systems.

Conclusion

In contrast to Petitioners' proposals, AMSC has a very realistic proposal for using the RDSS bands by integrating as much as possible of the uplink band into a system that also will use the MSS spectrum. This reduces dramatically the cost of putting the spectrum into service and eliminates the need to identify sufficient spectrum in the band for one or more entire systems. Therefore, based on the foregoing, AMSC respectfully

requests that the Commission grant AMSC's June 3 Petition and deny the Petitions for Rulemaking filed by Constellation, TRW and Ellipsat.

Respectfully submitted,

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Date: October 16, 1991

TECHNICAL APPENDIX

TECHNICAL APPENDIX

I. CONSTELLATION COMMUNICATIONS INC.

A. CCI's Proposals Lead to Harmful Interference

1. Conformance With PFD and EIRP Limits

The uplink EIRP of Aries user terminals is 3 dBW/4 kHz, which is 6 dB in excess of the limit prescribed by the Radio Regulations. CCI admits that it must exceed the power limit by up to 9 dB with its first generation system, and has requested a temporary waiver. Application, Appendix H, at 9. AMSC concurs with the relaxation of the uplink EIRP limit in the upper 10 MHz of the band. As AMSC has demonstrated, relaxation of the uplink EIRP limit is both feasible and desirable in the 1616.5-1626.5 MHz band, in which sharing with the radionavigation-satellite and radio astronomy services is encountered.[1] However, CCI's multiple entry proposals would require that Aries and other proposed systems be capable of operation below 1616.5 MHz, where a severe limit on EIRP is needed to facilitate sharing with radionavigation and radio astronomy systems.

The Aries downlink PFD at 2.4 GHz, however, exceeds the applicable RR limit by 2.8 dB at 5° elevation, as shown by the calculations in Table 1. This violation of PFD limits at low elevation angles is particularly onerous in the case of Aries because of the

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[1] See Comments of AMSC, Gen. Docket 89-554 (filed April 12, 1991), Technical Appendix at 4-8.

proposed use of Earth-coverage satellite antennas and the fact the satellites are in low-Earth-orbit. As an initial matter, the existing PFD limits were derived with respect to geostationary satellites which provide fixed reference locations for off-pointing of terrestrial receiver antennas when necessary. The Aries satellites, however, will spend considerable time in the main beams of terrestrial stations regardless of how the terrestrial station antenna is pointed. The existing PFD limits simply do not provide appropriate protection of terrestrial receivers from dense constellations of satellites such Aries.

2. Potential Interference to Other Services

CCI presents analyses of sharing with some of the services incumbent in the 1.6/2.4 GHz bands (Application, Appendix H). Reference is made below to these analyses.[2]

[2] In the context of its analyses, CCI states that Aries will achieve frequency reuse that exceeds that presently achieved by geostationary MSS systems.(Application, Appendix H, at 1) This is erroneous, in that Aries and current geostationary MSS systems both achieve only one nominal use of a frequency for service to mobile earth stations with omnidirectional antennas in the U.S. Of course, Inmarsat Standard A terminals (and Standard B prototypes) can achieve two-fold frequency reuse via geostationary satellites by virtue of earth station antenna discrimination (i.e., one use via Inmarsat AOR and one use via Inmarsat POR).

(a) Radio Astronomy

CCI fails to address the possibilities for frequency sharing between Aries and radio astronomy systems even though such sharing would be necessary under CCI's proposed multiple entry polices. The Aries system (and the systems of all other applicants) is incapable of sharing with radio astronomy on an interference-free basis. As shown by the calculations in Table 2, all Aries aircraft earth stations operating within or near the radio astronomy band would have to be located over 563 miles from any radio astronomy observatory. Similarly large distances could be needed for land and maritime users of the Aries system in light of the fact that several Aries users could simultaneously interfere with a radio astronomy receiver. Moreover, the six U.S. radio astronomy observatories using the 1.6 GHz band are dispersed in a manner that precludes Aries use of the lower portions of the 1610-1626.5 MHz band (see Table 3).

(b) Fixed Service

CCI presents no analysis of sharing between Aries downlinks and receivers in the fixed service in the 2483.5-2500 MHz band despite its PFD violation. Based on the preceding PFD calculation for Aries (Table 1), Table 4 shows that Aries would cause interference levels that are 8 dB and 22 dB in excess of the permissible levels for analog and digital links when an Aries satellite is located within several degrees of the

mainbeam of the fixed station. Thus, Aries will cause harmful levels of interference to receivers in the fixed service for substantial percentages of the time. (b) Fixed Service

A particularly onerous aspect of CCI's multiple entry proposals is that the interference caused to fixed stations at 2483.5-2400 MHz by Aries would be accompanied by the additional interference of all other proposed systems that would utilize non-geostationary satellites and spread spectrum modulation (e.g., TRW's Odyssey and Ellipsat's Ellipso I and Ellipso II). Each such satellite will periodically pass near and through the mainbeam of every terrestrial station, because there is simply no way for terrestrial station operators to avoid pointing at the orbit of a non-geostationary satellite. Further, several non-geostationary satellites associated with the multiple systems would simultaneously interfere with fixed service operations. Thus,
insofar as the existing PFD limit is considered to be too liberal for individual constellations of non-geostationary satellites such as Aries, even further tightening of the PFD limit would be needed to accommodate multiple satellite systems.

(c) Radionavigation-Satellite

As was the case with respect to radio astronomy, CCI's application omits any consideration of the interference that Aries would cause to radionavigation-satellite systems operating in the 1610-1616.5 MHz band. As shown by the calculations in Table 5, Aries operations below 1616.5 MHz would cause harmful levels of interference to the

GLONASS system even if it were assumed optimistically that 20 dB of GLONASS processing gain is available to reduce the effects of interference. Specifically, Aries users would cause potentially harmful interference to GLONASS receivers located 500 km (312 miles) away. Clearly, this is unacceptable to the aeronautical community, which is relying on interference-free access to GLONASS as part of the Global Navigation Satellite System. Of lesser but still potentially significant consequence is the fact that GLONASS satellites also would interfere with reception by Aries satellites.

(d) MSS

In its interference analyses, CCI completely overlooks the fact that a number of geostationary MSS system operators may need to implement portions of the band. As shown by the calculations in Table 6, the proposed Aries uplinks would generate C/I ratios in uplinks to geostationary MSS systems of between -1.0 and -3.8 dB under various operating conditions at times that Aries is operating near full-capacity levels. These C/I levels would result in complete disruption of MSS communications via geostationary satellites.

B. Capacity

CCI indicates that an Aries satellite can provide capacity for 50 voice channels (assuming a voice activity factor of 1.5) and that the footprint of an Aries satellite is large

enough to encompass the entire CONUS. Application, at 7 and Appendix A, at 25. Thus, although of two or more Aries satellites may at times cover portions of CONUS, the capacity available to CONUS would be 50 channels if CCI's claimed satellite capacity of 50 channels is true. However, CCI's estimate of the Aries satellite capacity ignores the fact that none of the proposed systems can use uplinks below 1616.5 MHz, the proposed Aries downlinks cannot operate at the high proposed PFD levels without causing harmful interference to terrestrial services, the CCI link budgets devote too little spacecraft power to each downlink, and the Aries spacecraft power available during eclipses is abysmally low. The fact is, even if one were to overlook the capacity adjustments that would be needed with respect to eclipse conditions, having too few channels to apply voice activity factors, and the reduction in available spectrum resources if Aries were considered as one of seven entrants under CCI's own proposed multiple entry scheme, the capacity of Aries for service to CONUS is no more than 1 voice channel as shown in Table 7. Thus, at best, the Aries capacity level is on par with that of "little LEOs" that have been proposed for operation below 1 GHz.

C. Reliability

1. Satellite Coverage and Visibility

CCI's low altitude constellation suffers the severe coverage and visibility problems

that have been revealed for the other proposed low-Earth-orbit MSS systems.[3] The space segment of CCI's proposed Aries system includes forty-eight (48) satellites at 1,019 km altitude, with twelve (12) satellites located in each of four polar orbital planes. CCI claims that Aries will provide global coverage 100% of the time (at 2 and Appendix A, at 2). CCI's coverage analysis of Aries is highly suspect in that, among other things, it is based upon perfect satellite station keeping that can not and should not be achieved. As an initial matter, the CCI application includes no information about the capabilities and tolerances for station keeping of the Aries satellites. It is obvious, however, that collisions would occur among Aries satellites if CCI succeeded in achieving the perfect station keeping assumed in its coverage depiction.[4]

In order to reduce collision probabilities, CCI's station keeping objective for each satellite must be to seek mean orbital locations and associated tolerance with respect to other satellites in the constellation in order to provide minimum separation distances (or

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[3] See Response of AMSC in the Matter of the Applications of Ellipsat Corporation and Motorola Satellite Communications, Inc. (filed August 5, 1991), Technical Appendix at 10-20.

[4] Under CCI's station keeping plan, two Aries satellites would be located exactly over the North Pole at the same altitude and over the South Pole at the same altitude at the same time. These satellites would approach one another at the polar collision points with closing speeds of about 37,500 km/hour (23,400 miles per hour). Upon collision, the satellites would be shattered into debris that would have long-lived and far-reaching impact on other space systems. These concerns are the subject of ongoing policy studies. See AMSC Reply Comments, Gen. Docket 89-554 (filed January 7, 1991), Technical Appendix, Exhibit 5.